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## Fish biodiversity and assemblages along the altitudinal gradients of tropical mountainous forest streams

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Knowledge of the fundamental aspects of ecology such as the patterns of fish species distribution and biodiversity in the forest streams is the first and basic step to develop effective conservation strategies. Yet, studies on altitudinal changes of fish composition and assemblages in Bornean forest streams are scarce despite being one of the hotspots of biodiversity conservation. Hence, surveys on freshwater fish composition along the altitudinal gradients of the Baleh River Basin in Sarawak, Borneo were conducted from April 2014 to August 2015. The Baleh River Basin was divided into seven altitudinal groups with a total of 72 stations. Group elevation ranged from 53 to 269 m above sea level. The fish samples and environmental parameters were taken concurrently during samplings. A total of 3565 specimens belonging to six orders, 14 families, and 76 species were found in the present study. The most dominant family in the Baleh River Basin was Cyprinidae (74.4%), followed by Gastromyzontidae (16.2%) while the most dominant species was *Tor tambra* (12.9%), followed by *Lobocheilos ovalis* (12.3%). Fish abundance significantly higher at high altitude sites than those at low altitude sites except for Mengiong River which has the lowest fish abundance despite with high elevation. Species richness was found significantly lower in midstream segment. Noticeable altitudinal gradient of fish assemblages was observed along the Baleh River except a discontinuity at the midstream segment which is attributable to the poorer quality inflow from the Mengiong River coupled with the meandering feature of the segment. Fish abundance was significantly and positively correlated with elevation, water pH and conductivity while negatively correlated with turbidity. Anthropogenic activities in the Baleh River Basin had altered the environmental variables thus disrupted the altitudinal gradient of fish assemblages. This phenomenon is apparent when the Canonical Correspondence Analysis (CCA) revealed that the first axis (CCA1) explained 42.5% of the variation and has positive loading on dissolved oxygen (DO) and negative loading on water conductivity; whereas CCA2 explained 37.5% of the variation and positively loaded on elevation, water pH, and DO. The results demonstrated that *Gastromyzon fasciatus* preferred more oxygenated water than *Protomyzon sp.*, *G. sp 1*, and *G. punctulatus* although they are all from Gastromyzontidae family that inhabiting high altitude sites. *Barbonymus schwanenfeldii* was also found most abundant with elevated dissolved oxygen value. On the other hand, *Rasbora volzii* and *R. hosii* inhabiting lower altitude sites with less oxygenated and more acidic water.

Altitudinal changes in the composition and biodiversity of fish fauna have been widely recorded<sup>1–4</sup>. Most of the studies covered a large scale of altitudinal gradient of fish assemblages, which are up to few thousand meters above sea level. For instance, the distinctiveness of the fish fauna had increased with elevation in streams of the central Andes of Colombia, where the greatest turnover was observed between 1000 and 1750 m above sea level, with nearly 90% of the species recorded between 250 and 1250 m above sea level<sup>1</sup>. Mercado-silva and Lyons investigated the fish assemblage patterns in a high gradient piedmont river in Mexico<sup>2</sup>. The authors demonstrated

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